

32 Mill Street Net-Zero Energy Retrofit

Warrior Home
Solar Decathlon Team

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Durability & Resilience Narrative

U.S. Department of Energy
Solar Decathlon 2023 Build Competition

32 Mill Street

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In partnership with the
**KW Urban Native
Wigwam Project**

Durability & Resilience Jury

Durability

The design of the building enclosure optimizes the thermal performance of the building through the use of closed cell spray foam applied directly on the inside face of the existing double wythe brick wall and mineral wool batt insulation with the service cavity. The choice to use a split approach when it came to choosing the wall insulation types was in the attempt to get the benefits from both materials. The spray foam has a higher thermal resistance to limit the thickness of the wall, is easy to install directly on the existing brick, and minimizes thermal bridging through service cavity studs. The addition of mineral wool within a 2"x4" service cavity on the inside of the spray foam layer was to provide ease when installing mechanical, electrical, and plumbing services. Furthermore, mineral wool is cheaper than spray foam and it is also easy to install. These materials are fairly common in residential applications however a wall is rarely split in this way in a typical home. Both spray foam and mineral wool have their advantages but when they are used together they can make for a much better overall wall assembly to fit the needs of Warrior Home's retrofit. Additionally, because of the heavily insulated wall, the home is designed for comfort all year round. The high thermal resistance isolates the interior environment from the exterior. All of these design decisions work together to ensure the completed build is sturdy and long lasting.

The existing roof shape provided issues for the solar array since it would lead to a complicated layout. Because of this a Fastrack aluminum rail system will be implemented as it provides the flexibility needed to have an efficient PV array. To guard the system from environmental factors, such as high winds, falling branches, or animals, a protective array perimeter meshing will be installed.

The materials that were selected for construction were chosen based on the performance goal for the retrofit, combined with knowledge of the extreme conditions the home will experience throughout the year. Cold winters and warm summers are expected in Kitchener, ON and were aspects of the site that were kept in mind when making decisions. Additionally, the snowfall in the winter can pose extra challenges. The solar panels are angled so that the snowfall will not pile up. The existing roof rafters were sistered to account for the increased weight of the solar panels and the expected snow loads.



The retrofit also functions to provide a long lasting design including maintenance, material performance, and owner operation. A heat recovery ventilator unit was specified to avoid inevitable humidity into the home and limit the condensation build up on the windows. It extracts the heat from the stale air leaving the house while bringing in new warm fresh air. The heat recycled from the stale air saves energy that would be wasted to heat the fresh air.

To further these techniques, the home owners will be instructed on the proper use of the systems in their home and daily tasks they can perform to extend service life and reduce maintenance.

Performance

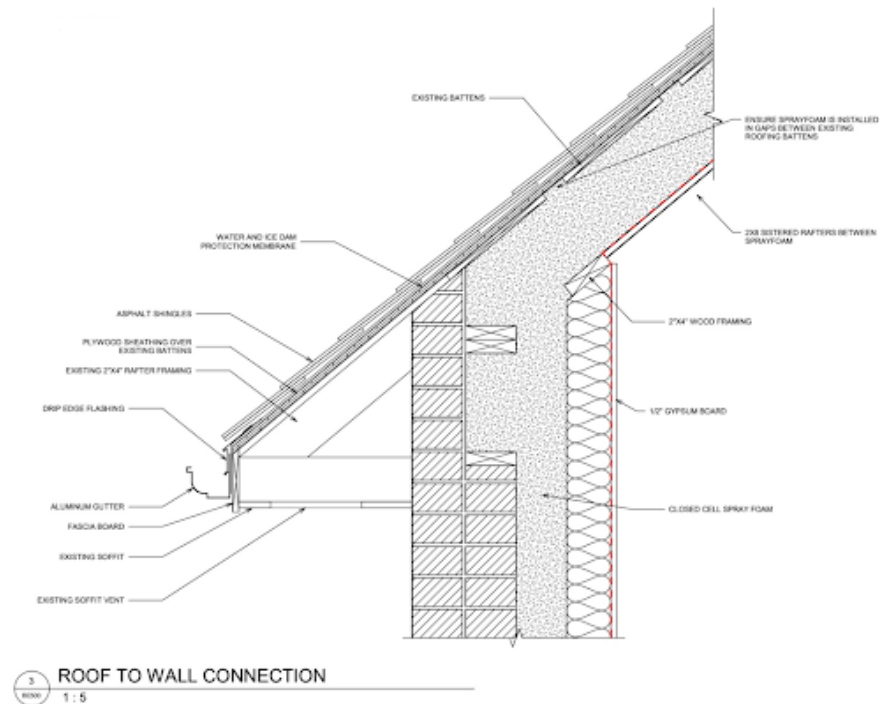
While the existing double wythe brick masonry walls would perform poorly in resisting lateral loads, such as wind and seismic loads, in the retrofit design they do not work alone. The floor joists of both the main and second floor are being sistered to aid the masonry walls in resisting those loads. This makes the structure better equipped to endure unforeseen disasters than it was previously. Additionally, while the 2"x4" service cavity on the inside of the exterior walls are not load bearing they still tie the floor joists together adding to the rigidity of the structure.

The continuous closed cell spray foam insulation helps to maintain energy within the home. Since all the wood studs for the service cavity are on the interior side of this continuous layer of insulation, it limits the thermal bridging within the wall assembly. This is particularly important during the cold of winter which Kitchener is subject to. The thermal performance is aided by the continual thermal layer between the wall assembly and the roof assembly shown in the figure below.

The spray foam from the wall assembly flows into the spray foam into the roof cavity and only ends at the start of the attic space where it is covered with a thick layer of blown in cellulose

insulation. This connection is typically a weak point for energy loss but with the continuous layer of insulation it limits the energy loss in this area.

In the retrofit, we are implementing a grid tied inverter and net metering to achieve net-zero energy usage. This eliminated the need



Resilience & Resource Management

In this retrofit design, Warrior Home focused on integrating passive strategies, material selection, life cycle and local strategies to maximize the resilience of the design. Moisture control is closely related with occupant comfort when on the subject of resilience. With the existing double wythe brick wall, there was a high potential for moisture build up within the assembly since there was no weather barrier nor any insulation. Moisture within the wall for extended periods of time without proper drying can lead to structural deterioration, in this case the crumbling of the brick masonry wall. Additionally, moisture can lead to mold and fungus issues which pose a risk to health and comfort. Furthermore, some insulation materials can settle or break down throughout its lifespan, which affect occupant comfort and safety. Keeping these items in mind, Warrior Home chose materials that would be sustainable throughout the lifetime of the building.

Since Warrior Home is working on a retrofit project, we were able to reuse many things including a lot of the structure. All of the existing joists, rafters, and masonry walls remain in the new design. All the joists and rafters will be sistered but the added lumber will still be less than needed for a new build. Additionally since we are keeping the brick exterior, we do not need to purchase or install a cladding system. This design limits the waste for the project and reduces the amount of materials needed to complete the project.

The average home in Canada uses about 11,135 kWh of energy in a year. Our planned solar array will be providing the home with about 11,000 kWh of energy in a year, meaning it will only use about 135 kWh from the grid directly. That is 98.8% less than a typical home in Canada.

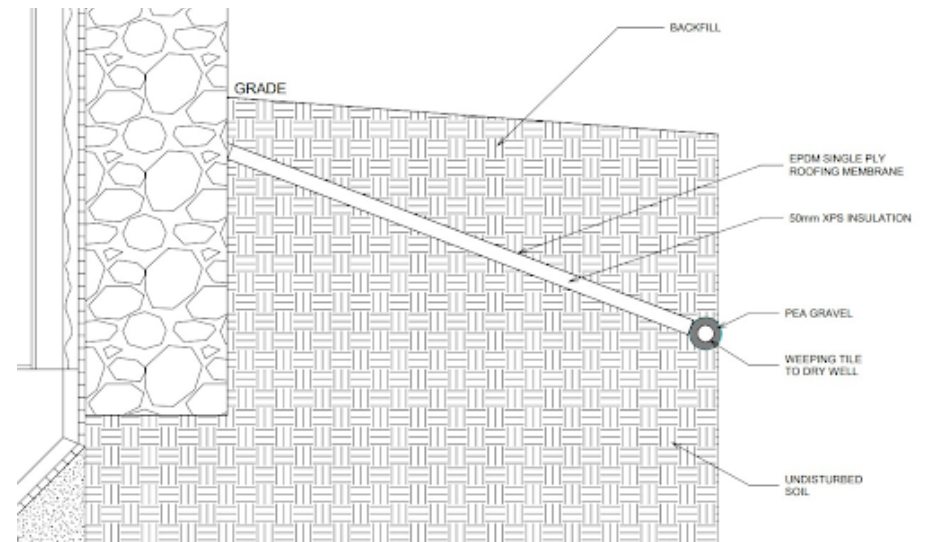


Innovation

The Warrior Home design team made the innovative choices when designing the new foundation system. Since the site is located in a flood zone one of the design goals for this area of the project was to limit the amount of water entering the foundation structure, whether it be during a flood or the common heavy precipitation. To do this Warrior Home proposed the rare solution of implementing slanted perimeter insulation covered in a single ply roofing membrane leading to a weeping tile.

The insulation provides extra thermal protection, keeping the soil surrounding the foundation warm in the winter months, limiting possible frost infiltration. The single ply roofing membrane installed above the insulation drives rainwater in the soil away from foundation walls. This reduces the stress put on the foundation walls as it will not have to interact with as much potential water penetration and freezing. This approach can also minimize future foundation repairs.

Another innovative approach made by the Warrior Home team was ensuring that there was constant communication with the clients throughout design and construction. By making sure that the homeowner was aware of what was going on and understood the processes taking place, they will be better at ensuring that the energy efficiency can be maintained. This is an innovative step because it is something that is not considered often during the design and construction processes. We recognize that this is a real home that will be occupied by real people with real needs.





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